

Claims

1. A loudspeaker comprising:
 - a sound generating element mounted on a support structure;
- 5 two rotary actuators mounted at opposing edges of the sound generating element and operable to drive motion of the sound generating element relative to the support structure by rotating said edges.
- 10 2. A loudspeaker according to claim 1, wherein the two rotary actuators are operable to drive motion including components of rotation in opposite senses if driven with a common drive signal.
- 15 3. A loudspeaker according to claim 1 or 2, wherein the two rotary actuators are identical.
4. A loudspeaker according to any one of the preceding claims, wherein the rotary actuators are piezoelectric actuators.
- 20 5. A loudspeaker according to claim 4, wherein the rotary actuators have a bender construction.
6. A loudspeaker according to claim 4 or 5, wherein the rotary actuators each extend in a curve between the sound generating element and the support structure.
- 25 7. A loudspeaker according to claim 6, wherein the curve is an arc of a circle.
8. A loudspeaker according to any one of claims 4 to 7, wherein each rotary actuator is longer in extent along the axis about which said rotation occurs on operation than in extent between the ends of the actuator which rotate on operation.
- 30 9. A loudspeaker according to any one of claims 4 to 8, wherein the rotary actuators are each coupled at one end to the sound generating element and at the other end to the support structure.

10. A loudspeaker according to any one of the preceding claims, further comprising a drive circuit for supplying a common drive signal to each actuator.
11. A loudspeaker according to any one of claims 1 to 9, further comprising a drive circuit for supplying a separate drive signal to each actuator.
12. A loudspeaker according to claim 11, wherein the drive circuit includes a low frequency mixer circuit arranged to mix a low frequency component of each of the separate drive signals into the other of the separate drive signals.
13. A loudspeaker according to claim 12, wherein the low frequency mixer circuit comprises:
 - two signal paths each for supplying one of the separate drive signals to a respective actuator;
 - 15 a filter arrangement arranged in each signal path to filter out said low frequency components of the two separate drive signals;
 - a signal processing circuit arranged to combine the low frequency components of the two separate drive signals filtered out by the filter arrangement and to re-introduce the combined low frequency components into each of the signal paths.
14. A loudspeaker according to claim 12 or 13, wherein the low frequency component is a component in a frequency band below a predetermined cut-off frequency.
15. A loudspeaker according to claim 14, wherein the predetermined cut-off frequency is 400Hz or less.
16. A loudspeaker according to any one of claims 11 to 15, wherein the drive circuit is arranged to process the separate drive signals by a head-related transfer function.
- 30 17. A loudspeaker according to any one of claims 11 to 16, wherein the drive circuit includes an opposition mixer circuit arranged to derive an opposition signal from each of the separate drive signals by inversion of at least a high frequency component thereof and

to mix each respective opposition signal with the other one of the separate drive signals from which the opposition signal was derived.

18. A loudspeaker according to any one of the preceding claims, wherein the sound generating element comprises a sheet having a physical property which varies across the sheet between the two actuators.

19. A loudspeaker according to claim 18, wherein said physical property varies across the sheet with mirror symmetry about a central line between the two actuators.

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20. A loudspeaker according to claim 18 or 19, wherein said physical property is stiffness.

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21. A loudspeaker according to claim 20, wherein the stiffness of the sheet is lower along a central line between the two actuators than in portions on either side of the central line.

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22. A loudspeaker according to claim 20 or 21, wherein the sheet comprises a material having uniform composition across the sheet and the thickness varies across the sheet between the two actuators.

23. A loudspeaker according to claim 18, wherein said physical property is thickness.

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24. A loudspeaker according to claim 23, wherein the sheet is transparent and disposed above a display device and the thickness varies across the sheet between the two actuators so that the sheet forms a lens.

25. A loudspeaker according to any one of the preceding claims, wherein the support is a portion of a housing of an electronic device.

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26. A loudspeaker according to claim 25, wherein the sound generating element is transparent and covers a display device.

27. A loudspeaker comprising:
a sound generating element mounted on a support structure;
two actuators mounted in opposite halves of the sound generating element and
operable to drive motion of the sound generating element relative to the support structure;
5 and
a drive circuit for supplying a separate drive signal to each actuator, including a low
frequency mixer circuit arranged to mix a low frequency component of each of the separate
drive signals into the other of the separate drive signals.

10 28. A loudspeaker comprising:
a sound generating element mounted on a support structure;
two actuators mounted in opposite halves of the sound generating element and
operable to drive motion of the sound generating element relative to the support structure;
and
15 a drive circuit for supplying a separate drive signal to each actuator, wherein the
drive circuit is arranged to process the separate drive signals by a head-related transfer
function to produce a directional effect..

29. A loudspeaker comprising:
20 a sound generating element mounted on a support structure;
two actuators mounted in opposite halves of the sound generating element and
operable to drive motion of the sound generating element relative to the support structure;
and
a drive circuit for supplying a separate drive signal to each actuator, including an
25 opposition mixer circuit arranged to derive an opposition signal from each of the separate
drive signals by inversion of at least a high frequency component thereof and to mix each
respective opposition signal with the other one of the separate drive signals from which the
opposition signal was derived.

30 30. A loudspeaker comprising:
a sound generating element mounted on a support structure;
two actuators mounted in opposite halves of the sound generating element and
operable to drive motion of the sound generating element relative to the support structure,

the sound generating element comprising a sheet having a physical property which varies across the sheet between the two actuators.